TeraStat, Inc

Memorandum

DATE: June 13, 2002

TO: Mark Myers/Williams Kastner Gibbs

FROM: Bruce Peterson

RE: Review of statistical addendum to appendix D. Trustee Report

This memorandum presents my review of the statistical analysis presented in the Addendum to Appendix D of the March 14, 2002, *Hylebos Waterway Natural Resource Damage Settlement Report*. It is my understanding that the purpose of the statistical addendum to appendix D of the Trustee Report is to compare the analytical results for PAHs and PCBs obtained from samples collected by HCC and similar samples collected by the Trustees.

The analysis examines the analytical results from two separate sets of samples. The Trustee samples were collected from locations an unspecified distance from the locations of the HCC samples at each station. Different analytical methods were used to quantify the concentrations of PAHs and PCBs in the two sets of samples. One goal of the addendum is to develop a "correction factor" to provide compatible results.

There are a number of methodological flaws in the statistical analysis presented in the addendum. Foremost is the confounding of spatial and analytical variability in the analytical results. Because the analytical results are from separate samples, differences in reported concentrations are due both to the differences in analytical techniques and the spatial variability of concentrations. The addendum does not address this issue nor attempt to quantify the relative contributions of spatial and analytical variability.

A second difficulty is the approach of estimating a "correction factor" to convert HCC concentrations into Trustee compatible concentrations. In essence, the "correction factor" approach is attempting to estimate the concentration that the Trustees would have found had they analyzed the HCC samples. The uncertainty of both sets of measurements is combined in the estimate of the "correction factor" so that the overall uncertainty of concentration estimates is increased.

Two types of analysis were conducted in the addendum. For the PAHs a linear regression approach was used to attempt to identify a relationship between concentrations reported by HCC and the Trustees. A correlation and mean ratio approach was used in the analysis of PCBs.

The linear regression approach for the PAH analysis is flawed. First, as discussed above, the relationship confounds spatial and analytical components of variability. In addition, changes were made to the data sets that tend to bias the analysis.

The Trustees report that they added a value of 0.0 to the data sets to "force fit the regression through the x-y intercept". Although regression estimates can be forced through the origin, adding a zero to the data sets does not do this. A review of the scatter plot and table shown in the addendum shows that the y-axis intercept is positive. A zero pseudo data point thus will bias the intercept smaller and make the slope greater. The authors do not specify how the "correction factor" is derived; but presumably, it corresponds to the slope of the regression equation. Thus by adding a zero value to the data set the authors have forced the "correction factor" for PAHs to be larger than it might otherwise be calculated.

The analysis for the PCB data uses the aroclor 1260 and 1254 concentrations from the HCC samples and twice the total congener concentrations from the Trustee samples. An explanation of the source of the factor 2 is not provided.

The Trustees state that a linear regression failed to find a significant relationship between the HCC PCB measurements and the Trustee PCB measurements.

The Trustees then used a Spearman rank correlation test to examine the correlation between the two data sets. The Spearmen rank correlation replaces the concentration values in each data set with the rank of the sample concentration in the data set. This transformation discards the magnitude of the concentration and instead tests if the samples with larger concentrations tend to come from the same station.

Thus, the Spearman rank correlation tends to show if the sample analyses are consistent (i.e. both tend to identify the same stations as having the same rank) but says nothing about the relative concentrations of the two sets of samples. In addition, because the correlation is based on ranks, it is resistant to the effect of outliers. Removing "outlier" data from a rank analysis is inappropriate.

The Trustees use the small (0.4) but significant r-square of the rank correlation as motivation for calculating the ratio of the overall mean concentrations from the two data sets to use as a "correction factor".

The mean concentrations used to calculate the "correction factor" ratio were based on selected data. Data values were included when the ratio between the two concentrations reported for a station was less than 4.0. The effect of this selection is seen in table 8 where the mean of values from table 7 (excluding HY-17) is 416 (Trustee) and 360 (HCC) but is shown in table 8 as 407 (Trustee) and 222 (HCC) after selective exclusion of data points.

The effect of overall variability (spatial and analytical) on the ratio estimate can be seen by comparing the ratios based on the 95th percentile confidence limits for the means.

Upper 95th/Lower 95th	482/71	6.8
Mean/Mean	416/360	1.2
Lower 95th/Upper 95th	351/651	0.5

Thus based on the variability of the data, a ratio of Trustee to HCC concentrations may range from 6.8 to 0.5. A ratio of mean concentrations that includes station-to-station variability and analytical variability is not appropriate.

TeraStat, Inc

Summary of Qualifications

Bruce A. Peterson, Ph.D., President

Dr. Peterson received his Ph.D. in statistics from Oregon State University, a MS in systems' analysis and a BA in physics from the State University of New York at Buffalo. He has over 20 years experience in statistical consulting and design of software systems incorporating statistical methods. TeraStat was founded to provide clients with cost effective tools for data based decisions.

Representative projects, products and activities

TeraStat provides clients with statistical consulting and custom software for implementing statistical operations. For the radiation processing industry, TeraStat has developed software and procedures for the non-linear calibration of dosimetry systems. Custom software for clients like Becton Dickinson and 3M has enabled the automation of dosimetry, greatly reducing labor requirements. TeraStat software links instrument readings to dose estimation and passes the results onto corporate databases. Security measures ensure compliance with 21CFR part 11 traceablity requirements.

For Boston Scientific, TeraStat developed non-destructive test methods to identify product quality using partial least squares regression to relate sample FTIR spectra to destructive test results. Because of this study, the client was able to identify process changes required to improve the yield of critical biomedical devices. Such procedures can be automated to use subtle changes in FTIR spectra to indicate product quality parameters otherwise only available through more expensive or destructive testing.

Dr. Peterson is a long-term participant on ASTM subcommittee E10.01 and co-authored the E1707-95 standard *Guide for Estimating Uncertainties in Dosimetry for Radiation Processing.* He works extensively with committees developing standards for radiation dose mapping, dosimetry system specification and acceptance, and the use of mathematical methods for dose calculations.

TeraStat supplies leading dosimeter manufacturing firms with quality control systems and audit capabilities. TeraStat also develop custom system integration solutions for dosimetry, enabling dosimeter manufacturers to provide complete systems to their clients.

TeraStat has also done extensive work with environmental compliance monitoring systems. TeraStat developed statistical procedures for monitoring industrial emissions using surrogate parameters to minimize data collection costs. These procedures utilize the statistical relationships among easily monitored process attributes and direct measurements of targeted emissions. At Weyerhaeuser Industries, these procedures allowed the company to meet regulatory monitoring requirements while saving over $4 million in monitoring costs

TeraStat has extensive experience with environmental sampling design and analysis. Typical projects involving environmental monitoring and contaminant source detection include landfills (e.g. TOSCO (CA), Roseville (CA), Mica (WA). Kent Highlands (WA),.Wykoff Industries (WA)), industrial sites (e.g. ASARCO, NW Alloys, Alcoa, Reichold Industries, SeaFab Metals, Simpson Pulp and Paper, Weyerhaeuser, Hughes Labs (CA), Chevron (Port Arthur TX)), military bases (e.g. naval stations at Barstow, North Island, 29 Palms, El Toro, Long Beach, and Wright Patterson AFB), mixed waste sites (e.g. Hanford, Oak Ridge). A key element for virtually every site was the need to work with regulatory authorities to identify appropriate statistical methods for environmental conditions differing from the standard regulatory model.

Dr. Peterson was the lead statistician for EPA's, $12 million Love Canal Habitability study; one of the earliest major environmental studies. The Love Canal site was characteristic of many more recent sites in the extremely litigious environment that prevailed among concerned parties. EPA's concern was to make a highly defensible decision that was protective of human health. This study pioneered procedures for maintaining data comparability among multiple laboratories, designs for robust sampling, near real time data quality review, integration of data management and GIS tools, and presentation of complex results to potentially litigious parties. Statistical methods developed during this study included methods to estimate the detection limit for instruments, such as the GC/MS, that produce complex multivariate results.

Bruce A. Peterson

EDUCATION

Oregon State University, Statistics, Ph.D.

State University of New York at Buffalo, Systems Analysis, MS

State University of New York at Buffalo, Physics, BA

AFFILIATIONS

American Society for Testing and Materials

American Society for Quality Control

American Statistical Association

American Association for the Advancement of Science

SELECTED PUBLICATIONS AND PRESENTATIONS

Measurement Uncertainty. Plenary presentation at the Fourth International Workshop on Dosimetry for Radiation Processing, San Diego, CA. October, 2000

Predictive Emissions Models. Presented at NCASI regional meeting, Portland, OR September, 2000

Calibration and the effect of Measurement Uncertainty. Guest lecture at the National Research Center for Statistics and the Environment, University of Washington, February, 1997.

Data Sufficiency and Decision Making for Site Remediation, Seminar series at University of Wisconsin (Patrick Eagin, University of Wisconsin, Seminar organizer) . Guest Lecturer 1990,91,92,93,94,95 series.

Design of a Soil Sampling Study to Determine the Habitability of the Emergency Declaration Area, Love Canal, New York. Environmetrics 1990 (1) 89-119 with Diane Lambert and Irma Terpenning

Nondetects, Detection Limits, and the Probability of Detection. Journal of the American Statistical Association, 1991 Vol 86 (414) 266-277

Performance of GC/MS Quality Indicators. Proceedings of the 10th National Conference of The Hazardous Materials Control Research Institute. November 1989.

The Love Canal Habitability Study. Invited presentation at the Joint Meeting of the American Statistical Association. August, 1988.

Comparison with Background Environment: Strategies for Design. Proceedings of the ASA/EPA Conference on Sampling and Site Selection in Environmental Studies. USEPA 1987

Composite Tomography: a Method for Estimating the Extent of Surface Contamination. Presented at the Joint Meeting of the American Statistical Association, August 1987.